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DRAFT

Bioventing Pilot Test Work Plan for Spill Site 6
F.E. Warren AFB, Wyoming

ENGINEERING-SCIENCE

Prepared For

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

90 CES/CEVR
F.E. Warren AFB, Texas

ES
Engineering-Science, Inc.
1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290

March 1993

AQM01-03-0562

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DRAFT
BIOVENTING PILOT TEST WORK PLAN FOR SPILL SITE 6 F.E. WARREN AFB, WYOMING

Prepared for:

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

90 CES/CEVR
F.E. Warren Air Force Base, Wyoming

by:

Engineering-Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado

March 1993

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FIGURES

FIGURES

DRAFT BIOVENTING TEST WORK PLAN FOR SPILL SITE 6 F.E. WARREN AFB, WYOMING

1.0 INTRODUCTION

This work plan presents the scope of an *in situ* bioventing pilot test for treatment of fuel-contaminated soils at spill site 6 at F.E. Warren Air Force Base (AFB), Wyoming. The scope of soil gas surveys to determine the feasibility of bioventing pilot test at Fire Protection Training Area 2 (FPTA 2) and the motor maintenance shop is also presented. The pilot test has three primary objectives: 1) to assess the potential for supplying oxygen throughout the contaminated soil interval, 2) to determine the rate at which indigenous microorganisms will degrade fuel when stimulated by oxygen-rich soil gas, and 3) to evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated to concentrations below regulatory standards.

The pilot test at Spill Site 6 will be conducted in two phases. One vent well (VW) and several monitoring points (MPs) will be installed during site investigation activities. The initial stage will also include an *in situ* respiration test and an air permeability test. This initial testing is expected to take approximately 2 weeks. If successful, ES will proceed directly into the second phase of testing. During the second phase, a bioventing system will be installed and monitored over a 1-year period.

If bioventing proves to be feasible at this site, pilot test data could be used to design a full-scale remediation system and to estimate the time required for site cleanup. An added benefit of the pilot testing at spill site 6 is that a significant amount of the fuel contamination should be biodegraded during the 1-year pilot test, as the testing will take place within the most contaminated soils at the site.

Additional background information on the development and recent success of the bioventing technology is found in the *Test Plan and Technical Protocol For A Field Treatability Test For Bioventing* (Hinchee et al., 1992). This protocol document will also serve as the primary reference for pilot test well designs and detailed procedures which will be used during the test.

2.0 SITE DESCRIPTION

2.1 Spill Site 6

2.1 Site Location and History

Spill site 6 is located in the courtyard of Building 316 and in the yard south of the building. Building 316 is located approximately 800 feet north of Crow Creek and 500 feet east of Sixth Street (Figure 2.1). The area of greatest contamination within the spill site appears to be near the southwestern corner of Building 316. An aboveground diesel storage tank was removed from this area in 1990. Figure 2.2 shows the locations of existing monitoring wells and soil sampling points within and adjacent to spill site 6.

The courtyard of Building 316 (Figure 2.2) has been used as a new and waste oil accumulation point by Power Production since at least 1962. Drums of oil were still being stored on the site in 1985. Numerous spills have been reported in the courtyard area. An aboveground diesel storage tank was removed from an area near the southwestern corner of the Building 316 in 1990. Evidence of diesel fuel spillage was evident in the soil beneath the tank. Until 1982, waste battery acid was disposed of on the ground in the courtyard. The yard south of Building 316 has served as radiator cleaning area.

2.1.2 Site Geology

Quarternary terrace deposits ranging from 4 to 12 feet thick overlie the Ogallala Formation in the vicinity of spill site 6. These deposits consist of sand to sandy gravels with some isolated clay lenses. Well 66 penetrated gravel and clay below a 6-foot clay layer that is estimated to be the top of the Ogallala Formation.

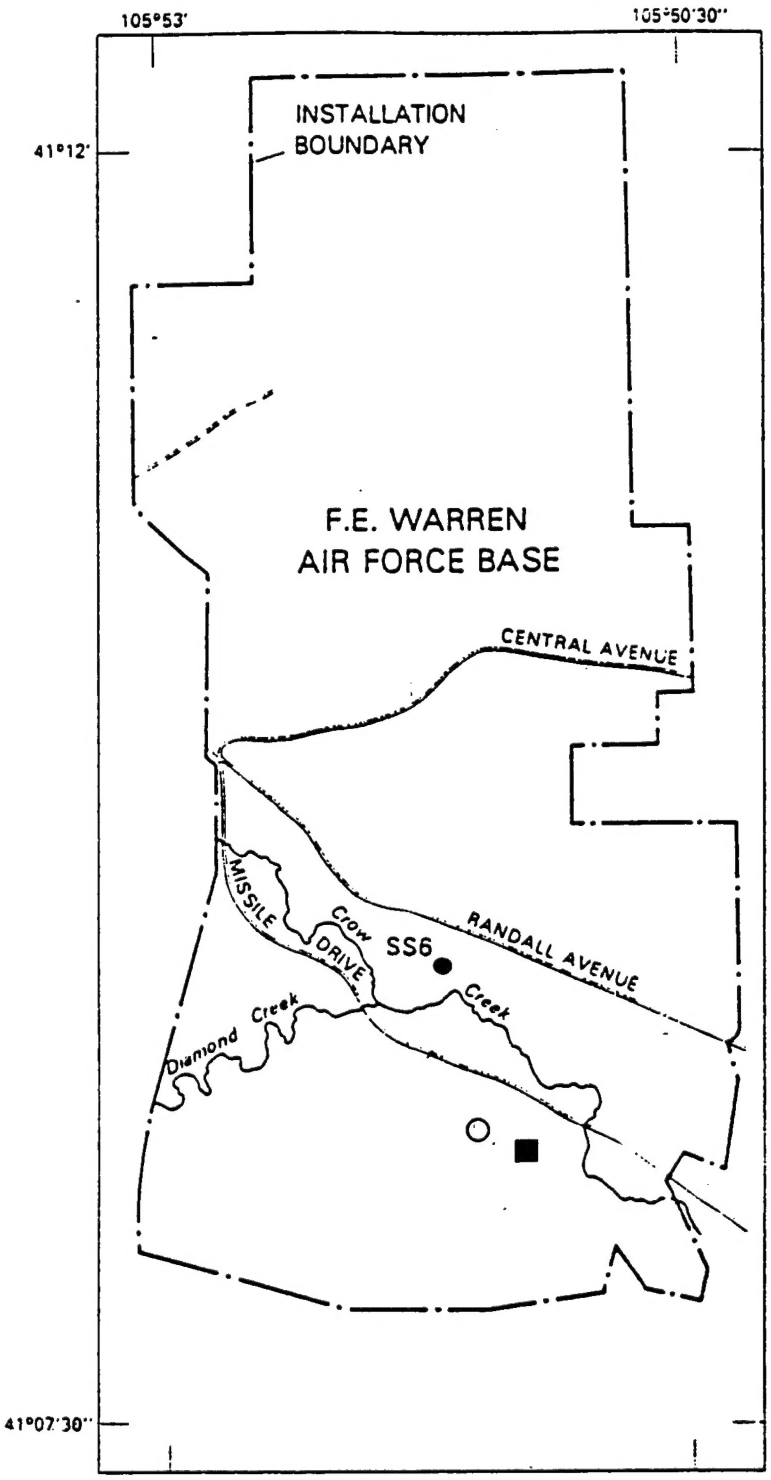
Groundwater occurs at approximately 13 feet below ground surface (bgs) at well 66. Water table contours indicate that local groundwater movement is to the south toward Crow Creek.

2.1.3 Site Contaminants

The primary contaminants of concern at spill site 6 are petroleum hydrocarbons in the vicinity of the former location of the diesel storage tank. This tank, located near the southwestern corner of Building 316, was removed in 1990. During the removal action, contaminated soil was noted underneath the tank. Total petroleum hydrocarbon (TPH) in soil samples from borehole 188, located near the tank site, ranged from 9,100 milligrams per kilogram (mg/kg) at 4-6 feet bgs, to 850 mg/kg at 6-8 feet bgs. Subsurface contamination (below approximately 3.5 feet) appears to be confined to the immediate vicinity of borehole 188. Sampling at boreholes 185, 186, and 189 detected no hydrocarbons. In addition, downgradient sampling at boreholes 1 and 2 did not detect any petroleum hydrocarbons.

2.2 Potential Additional Sites

The option to perform a bioventing pilot test at one additional site at F.E. Warren AFB exists. Because no additional site with significant subsurface contamination has been identified, two potential bioventing sites, FPTA 2 and a site



0 1,200 2,400 FEET

0 600 METERS

LEGEND

SS6 SPILL SITE 6

FIRE PROTECTION TRAINING AREA 2

MOTOR MAINTENANCE SHOP

FIGURE 2.1

SPILL SITE 6 AND FIRE PROTECTION TRAINING AREA 2 LOCATION WITH RESPECT TO BASE

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Source: U.S.G.S., 1991.

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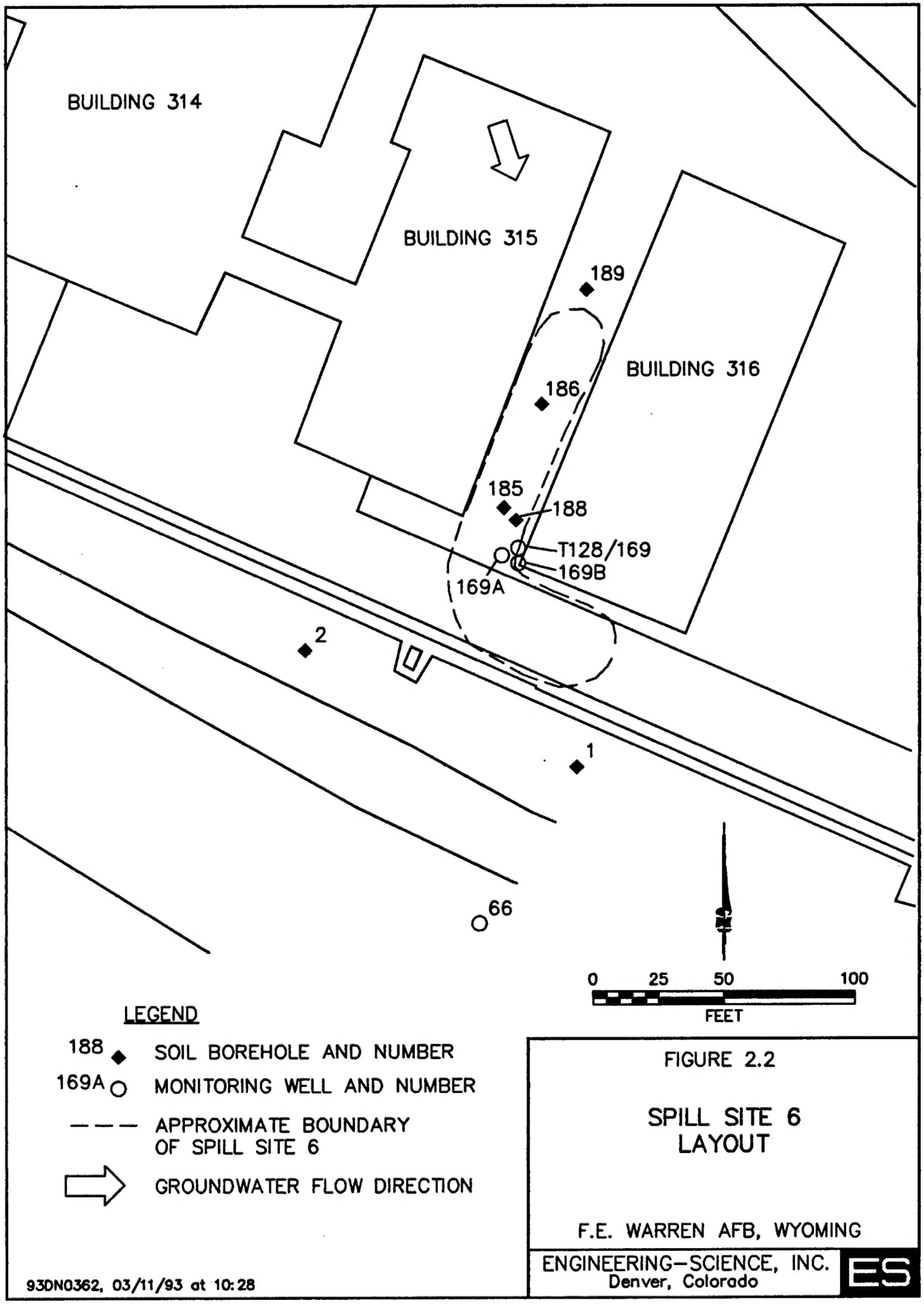

FIGURE 2.2

SPILL SITE 6
LAYOUT

F.E. WARREN AFB, WYOMING

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Denver, Colorado

near the Motor Maintenance Shop, will be investigated during field activities for Spill Site 6. Investigation will consist of a limited soil gas survey in each of the areas, conducted according to the protocol document Section 5.1 (Hinchee et al., 1992).

If a significant volume of soil with depleted oxygen (less than 2 percent) is located at either site, that site may be selected for a bioventing pilot test. Only one additional site will be selected. Should neither site prove feasible for a bioventing pilot test site, bioventing pilot testing will only be performed at Spill Site 6, at this time.

2.2.1 Fire Protection Training Area 2

Fire Protection Training Area 2 (FPTA 2) is located 0.25 mile south of Crow Creek between Omaha and Missouri Avenues and between Third and Fourth Streets. Between 1965 and 1974, waste oils, solvents, hydraulic fluids, and other combustible fluids were burned during fire training exercises. After 1974, only JP-4 was burned (Engineering Science, Inc., 1985). Operation of FPTA 2 was discontinued in 1989. Investigation results indicate that some TPH contamination in the soils exists at FPTA2. The contamination does not appear to be evenly distributed or at high concentrations. In one borehole, TPH was detected at 340 mg/kg at 8 to 10 feet bgs (U.S. Geological Survey, 1991).

To screen this site for potential bioventing applications, ES will conduct a limited soil gas survey near the most contaminated borehole to determine if soil gas has been depleted of oxygen as a result of ongoing degradation of hydrocarbons. Soil gas samples will be analyzed for total volatile hydrocarbons (TVH), oxygen, and carbon dioxide. If oxygen levels have been depleted to levels below 2 percent, the site will be instrumented for a bioventing pilot test using the general test layout and methods described in Section 3.

2.2.2 Motor Maintenance Shop

An area of petroleum hydrocarbon contamination has been identified east of Building 810, the Motor Maintenance Shop. The area is a dirt gravel parking lot, and contamination is known to exist in the upper 2.5 feet of soil. Based on presently available data, it does not appear that deeper contamination exists.

To screen this site for potential bioventing applications, ES will conduct a limited soil gas survey to determine if soil gas has been depleted of oxygen as a result ongoing degradation of hydrocarbons. Soil gas samples will be analyzed for total volatile hydrocarbons (TVH), oxygen, and carbon dioxide. If oxygen levels have been depleted to levels below 2 percent, the site will be instrumented for a bioventing pilot test using the general test layout and methods described in Section 3. If little contamination exists below three foot or if oxygen levels below 3 feet are greater than 2 percent, the site will be recommended for soil excavation and aboveground biotreatment.

3.0 PILOT TEST ACTIVITIES

The purpose of this section is to describe the work that will be performed by Engineering-Science, Inc. (ES) at the spill site 6 area during the bioventing pilot test. Activities that will be performed include siting and construction of a central air injection VW and three vapor MPs; an *in situ* respiration test; an air permeability test; and the installation of a long-term bioventing pilot test system. Soil and soil gas sampling procedures and the blower configuration that will be used to inject air (oxygen) into contaminated soils through the central VW are also discussed in this section. No dewatering will take place during the pilot test. Pilot test activities will be confined to unsaturated soils remediation. Existing monitoring wells will not be used as primary air injection wells. However, monitoring wells which have a portion of their screened interval above the water table may be used as vapor MPs or to measure the composition of background soil gas.

3.1 Site Layout

General descriptions of criteria for siting a central VW and vapor MPs are included in the protocol document (Hinchee et al., 1992). Figure 3.1 illustrates the proposed locations of the central VW and the MPs at this site. The final locations of these wells may vary slightly from the proposed locations if significant fuel contamination is not observed in the boring for the VW. Based on existing site investigation data, the central VW should be located near borehole 188 (Figure 2.2). A soil gas survey may be performed prior to drilling to determine the best locations for the central VW and MPs. Soils in this area are expected to be oxygen depleted (<2%) due to high hydrocarbon levels, and increased biological activity should be stimulated by oxygen-rich soil gas ventilation during pilot test operations.

Due to the relatively shallow depth of contamination at this site, the potential radius of venting influence around the central air injection well is expected to be 20 to 25 feet. Three vapor MPs (MPA, MPB, and MPC) will be located within a 25-foot radial distance of the central VW. The background MP previously installed near the Fire Training Pit 1 will be used to measure background levels of oxygen and carbon dioxide and to determine if natural carbon sources are contributing to oxygen uptake during the *in situ* respiration test.

3.2 Vent Well

One central VW will be installed at the site. The VW will be constructed of 4-inch inside-diameter (ID) Schedule 40 polyvinyl chloride (PVC), with a 5-foot interval of 0.04-inch slotted screen set at 5 to 10 feet bgs. Flush-threaded PVC casing and screen with no organic solvents or glues will be used. The filter pack will be clean, well-rounded silica sand with a 6-9 grain size, and will be placed in the annular space of the screened interval. A 3-foot layer of bentonite pellets, hydrated in place with potable water, will be placed directly over the filter pack. This layer of pellets will prevent the addition of bentonite slurry from saturating the filter pack. A bentonite/cement grout will then be tremied into the remaining annular space above the bentonite pellets to produce an air-tight seal above the screened interval. A complete seal is critical to prevent injected air from short circuiting to the surface

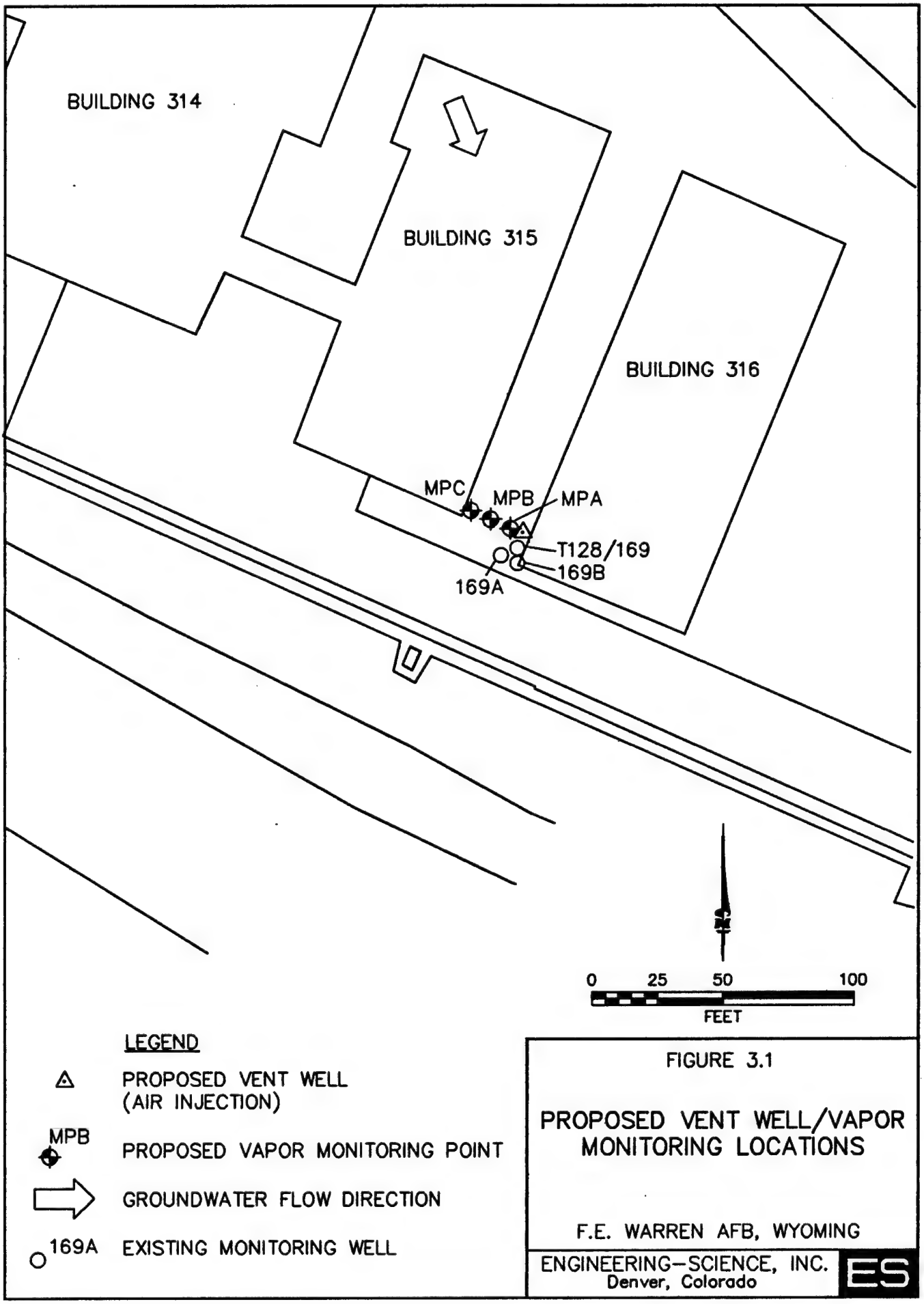

FIGURE 3.1

PROPOSED VENT WELL/VAPOR MONITORING LOCATIONS

F.E. WARREN AFB, WYOMING

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Denver, Colorado

during the bioventing test. Figure 3.2 illustrates the proposed central VW construction for this site.

Although contaminated soils exist above 5-feet bgs, the 5-foot depth was chosen for the top of the screened interval to reduce short circuiting of injected air to the surface, a common problem at sites with shallow contamination. It is felt that oxygen can still be delivered to the shallow soils by vertical flow and diffusion. Based on the initial soil gas survey in the pilot test area and conditions found during drilling, the VW screening interval may be reconsidered.

3.3 Monitoring Points

Three vapor MPs will be installed at the site at 5, 15, and 25 feet from the VW. A typical multidepth vapor MP installation for this site is shown in Figure 3.3. Soil gas oxygen and carbon dioxide concentrations will be monitored at depths of 3 feet, and 8 feet at each location. Multidepth monitoring will confirm that the entire soil profile is receiving oxygen, and will be used to measure fuel biodegradation rates at each depth. The spaces between monitoring intervals will be sealed with bentonite to isolate the intervals. Additional details on VW and MP construction are found in Section 4 of the protocol document. Existing monitoring wells T169, T169A, and T169B may be used as additional MPs if they are screened in the vadose zone.

3.4 Handling of Drill Cuttings

Cuttings will be collected in U.S. Department of Transportation (DOT) approved containers. The containers will be labeled and left on site. Drill cuttings will become the responsibility of F.E. Warren AFB, or their designated contractor, and will be analyzed and disposed of in accordance with the current procedures for ongoing remedial investigations.

3.5 Soil and Soil Gas Sampling

3.5.1 Soil Samples

Three soil samples will be collected from the pilot test area during the installation of the central VW and MPs and one soil sample will be collected near the existing background MP. Sampling procedures will follow those outlined in the protocol document. A total hydrocarbon vapor analyzer will be used during drilling to screen split-spoon samples for intervals of high fuel contamination in the VWs and MPs. One sample will be collected from the most contaminated interval of the central VW boring, and one sample will be collected from the interval of highest apparent contamination in each of the borings for the two MPs closest to the central VW. Soil samples will be analyzed for TPH; benzene, toluene, ethylbenzene, and xylenes (BTEX); soil moisture; pH; particle sizing; alkalinity; total iron; and nutrients. The background soil sample will be analyzed for total Kjeldahl nitrogen (TKN) only.

Samples for TPH and BTEX analysis will be collected using a split-spoon sampler containing brass tube liners. These soil samples will be immediately trimmed, and the ends of the brass tubes will be sealed with aluminum foil or

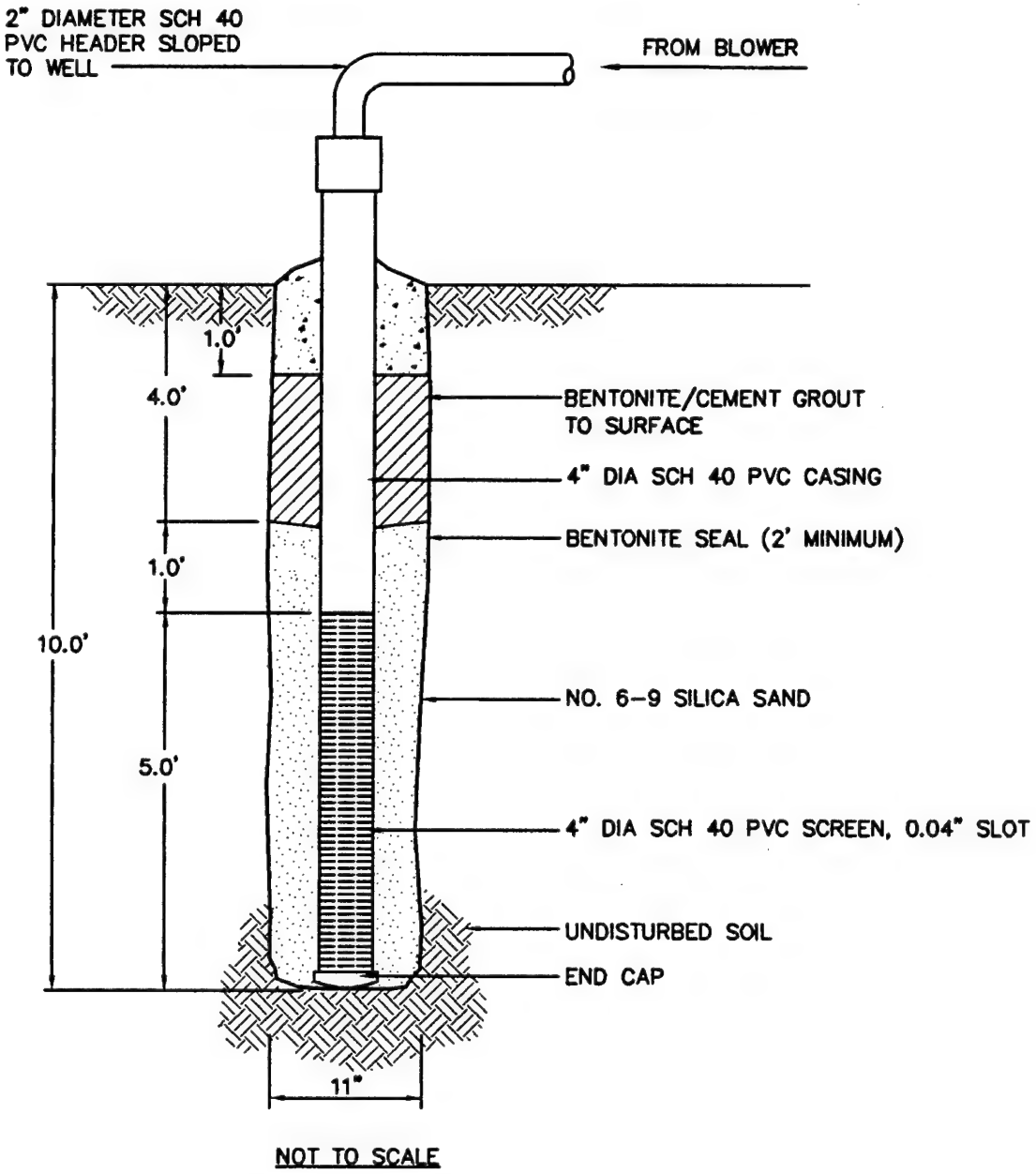

FIGURE 3.2

SPILL SITE 6
PROPOSED INJECTION VENT WELL
CONSTRUCTION DETAIL

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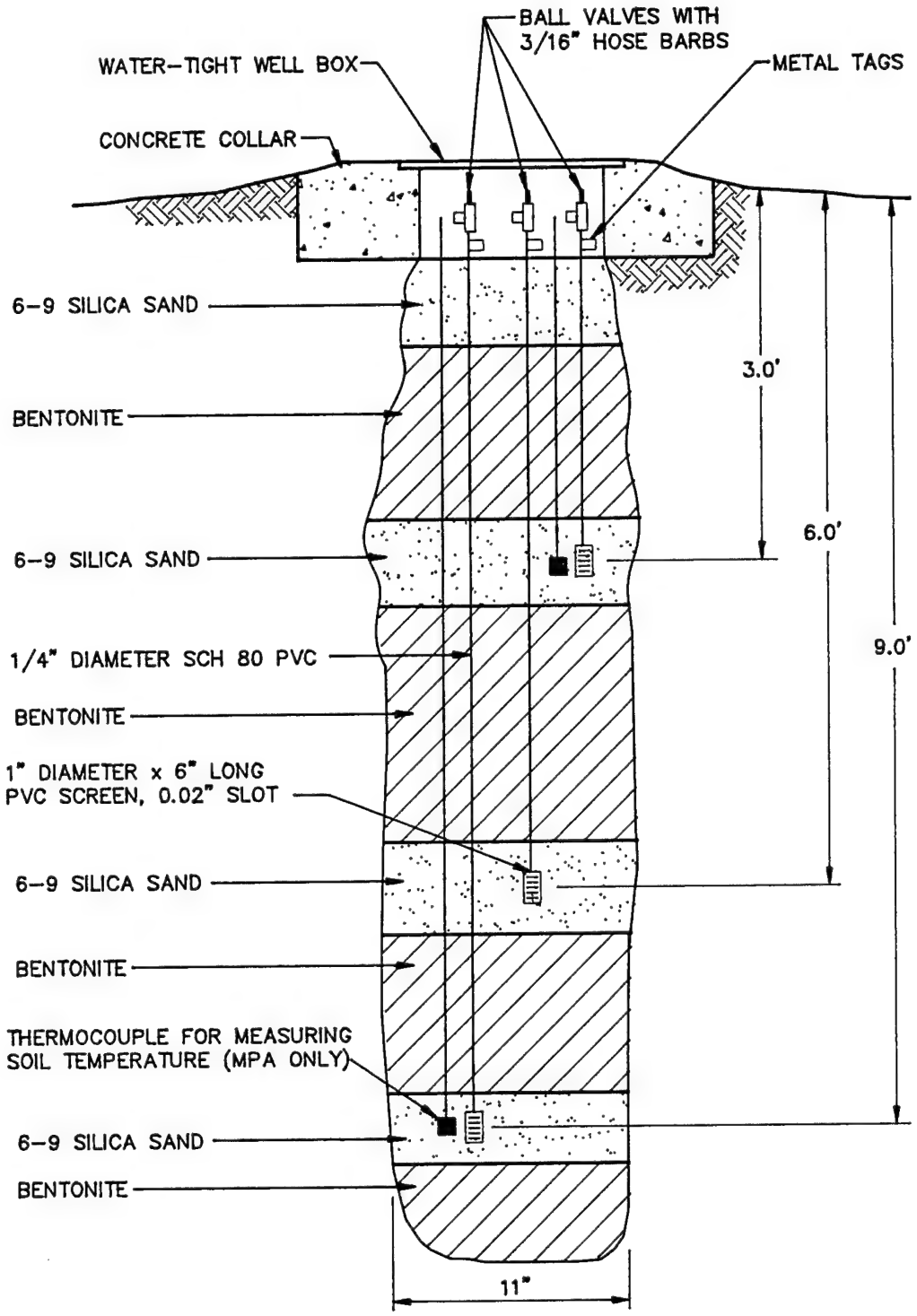

NOT TO SCALE

FIGURE 3.3

SPILL SITE 6
PROPOSED MONITORING POINT
CONSTRUCTION DETAIL

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Teflon® fabric held in place by plastic caps. Soil samples collected for physical parameter analyses will be placed into glass sample jars or other appropriate sample containers specified in the base sample handling plan. Soil samples will be labelled following the nomenclature specified in the protocol document (Section 5), wrapped in plastic, and placed in a cooler for shipment. A chain-of-custody form will be filled out, and the cooler will be shipped to the ES laboratory in Berkeley, California for analysis. This laboratory has been audited by the Air Force and meets all quality assurance/quality control (QA/QC) and certification requirements for the State of California.

3.5.2 Soil Gas Samples

Initial soil gas samples from the central VW and from the MPs closest to and furthest from the VW will be collected in SUMMA® canisters in accordance with the *Bioventing Field Sampling Plan* (Engineering-Science, Inc., 1992). Additionally, these soil gas samples will be used to determine the reduction in BTEX and TVH during the 1-year test, and to detect any migration of these vapors from the source area.

Soil gas sample canisters will be placed in a small cooler and packed with foam pellets to prevent excessive movement during shipment. Samples will not be sent on ice to prevent condensation of hydrocarbons. A chain-of-custody form will be filled out, and the cooler will be shipped to the Air Toxics, Inc. laboratory in Rancho Cordova, California for analysis.

3.6 Blower System

A 3-horsepower (hp) positive-displacement blower capable of injecting air over a wide range of flow rates and pressures will be used to conduct the initial air permeability test and *in situ* respiration test. The maximum power requirement anticipated for this pilot test is 230-volt, single-phase, 30-amp service. Additional details on power supply requirements are described in Section 5.0, Base Support Requirements.

3.7 In Situ Respiration Test

The objective of the *in situ* respiration test is to determine the rate at which soil bacteria degrade petroleum hydrocarbons. Respiration tests will be performed at selected depth intervals in MPs where bacteria biodegradation of hydrocarbons is indicated by low oxygen levels and elevated carbon dioxide concentrations in the soil gas. One-cubic-foot-per-minute (cfm) pumps will be used to inject air into the selected MP depth intervals containing low levels (<2%) of oxygen. A 20-hour air injection period will be used to oxygenate local contaminated soils. At the end of the 20-hour air injection period, the air supply will be cut off, and oxygen and carbon dioxide levels will be monitored for the following 48 to 72 hours. The decline in oxygen and increase in carbon dioxide concentrations over time will be used to estimate rates of bacterial degradation of fuel residuals. A helium tracer will also be injected at each MP used for respiration testing to ensure that oxygen loss due to diffusion or leakage is accounted for. Additional details on the *in situ*

respiration test are found in Section 5.7 of the protocol document (Hinchee et al., 1992).

3.8 Air Permeability Test

The objective of the air permeability test is to determine the extent of the subsurface that can be oxygenated using one air injection VW. Air will be injected into the 4-inch-diameter central VW using the blower unit, and pressure response will be measured at each MP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the MPs to verify that oxygen levels in the soil increase as the result of air injection. One air permeability test lasting approximately 4 to 8 hours will be performed.

3.9 Installation of 1-Year Pilot Test Bioventing System

A long-term bioventing system also will be installed at the spill site 6 area immediately following initial testing. The base will be requested to provide power, including 230-volt, 30-amp, single-phase service and a breaker box with one 230-volt receptacle and two 110-volt receptacles. Depending on the availability of a base electrician, the base electrician or a licensed electrician subcontracted to ES will assist in wiring the blowers to line power. The blower will be a 1-hp, rotary-vane blower capable of injecting air at 5 pounds per square inch (psi) and 14 cfm. The blower will be provided with vacuum, pressure, and temperature gauges, and an air filter, pressure relief, and flow control valve (see Figure 3.4). The blower will be housed in a small, prefabricated shed to provide protection from the weather. The system will be operated for 1 year, and every 6 months ES personnel will conduct *in situ* respiration tests to monitor the long-term performance of this bioventing system. Weekly system checks will be performed by F.E. Warren AFB personnel. If required, major maintenance of the blower unit will be performed by ES-Denver personnel. Detailed blower system information and a maintenance schedule will be included in the operation and maintenance (O&M) manual provided to the base. More detailed information regarding the long-term pilot test procedures can be found in the protocol document.

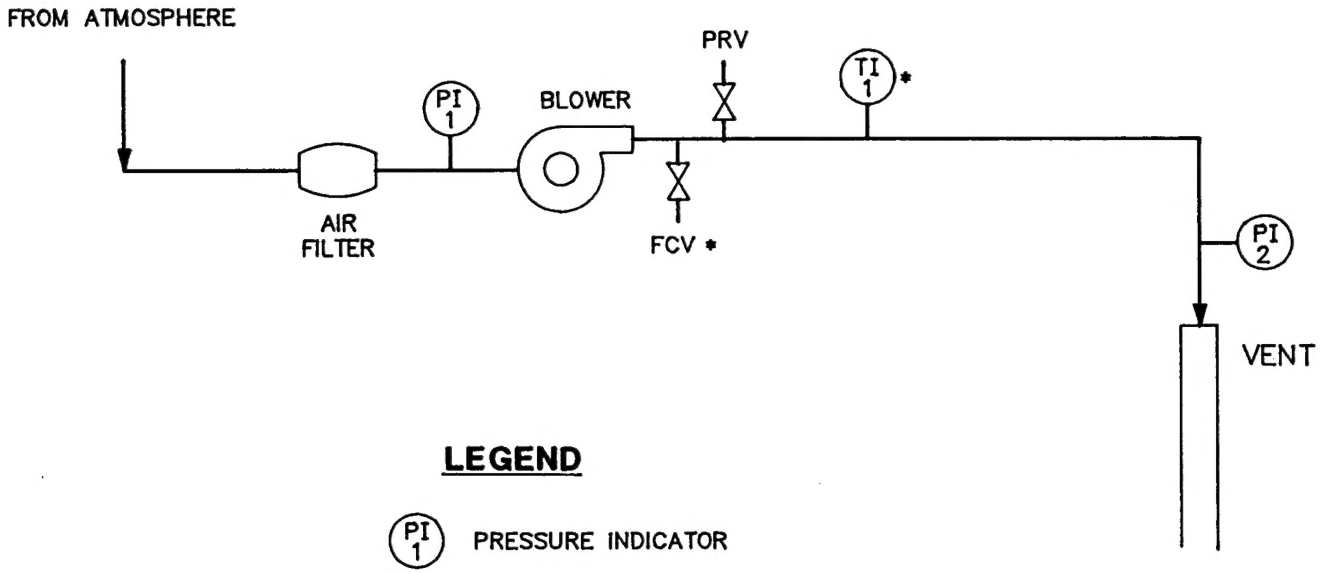
4.0 EXCEPTIONS TO PROTOCOL PROCEDURES

The procedures that will be used for initial soil gas surveys and to measure the air permeability of the soil and *in situ* respiration rates are described in Sections 4 and 5, respectively, of the protocol document (Hinchee et al., 1992). No exceptions to the protocol procedures are anticipated.

5.0 BASE SUPPORT REQUIREMENTS

The following base support is needed prior to the arrival of the drilling subcontractor and the ES pilot test team:

- Assistance in obtaining drilling and digging permits.
- Confirmation of available power source, including 230-volt, 30-amp, single-phase service and a breaker box with one 230-volt receptacle and two 110-volt receptacles near the southwest corner of Building 316.



LEGEND

PI 1	PRESSURE INDICATOR
TI 1	TEMPERATURE INDICATOR
FCV	FLOW CONTROL VALVE
PRV	PRESSURE RELIEF VALVE
*	OPTIONAL

FIGURE 3.4

SPILL SITE 6

BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION

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- Provision of any paperwork required to obtain gate passes and security badges for approximately three ES employees, two drillers, and an electrician (if a base electrician is not available). Vehicle passes will be needed for one truck and trailer, and a drill rig.

During the initial testing, the following base support is needed:

- Twelve square feet of desk space and a telephone in a building located as close to the site as practical.
- The use of a facsimile machine for transmitting 15 to 20 pages of test results.
- A decontamination pad where the driller can clean augers between borings.
- Acceptance of responsibility for drill cuttings from VW and MP borings, including any drum sampling to determine hazardous waste status. (If ES is to transfer custody of barrels to another contractor working on the base, assistance in arranging this transfer will also be needed.)

During the 1-year extended pilot test, base personnel will be required to perform the following activities:

- Check the blower system once per week to ensure that it is operating and to record the air injection pressure. ES will provide a brief training session on this procedure.
- If the blower stops working, notify Mr. Brian Blicker or Mr. Doug Downey of ES-Denver, (303) 831-8100; or Mr. Jerry Hansen of the Air Force Center for Environmental Excellence (AFCEE), (512) 536-4353.
- Arrange site access for an ES technician to conduct *in situ* respiration tests approximately 6 months and 1 year after the initial pilot test.

6.0 PROJECT SCHEDULE

The following schedule is contingent upon approval of this pilot test work plan and fulfillment of base support requirements.

Event	Date
Draft Pilot Test Work Plan to AFCEE/F. E. Warren AFB	23 March 1993
Begin Initial Pilot Test	17 May 1993
Interim Results Report	28 June 1993
Respiration Test	November 1993
Final Respiration Test	May 1994

7.0 POINTS OF CONTACT

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8.0 REFERENCES

Engineering-Science, Inc. 1992. *Field Sampling Plan for AFCEE Bioventing.* Denver, Colorado.

Hinchee, R. E., S. K. Ong, R. N. Miller, D. C. Downey, and R. Frandt, 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* January.

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